Summary of Technical Concerns for OU1 Groundwater Remediation

1. TCE is heavier than water and dissolved TCE will migrate both horizontally and vertically in the aquifer. GAFB should demonstrate the screen intervals are designed to intercept apparent plume migration routes for all monitoring and extraction wells. Detailed geological cross sections with clear definitions of sands, silts and clays should be provided to demonstrate effectiveness of monitoring and extraction wells. Past OU1 cross sections do not satisfy this need. The following table lists screened intervals of each extraction wells with nearby monitoring wells.

Well	Top of Scrn	Bottom of Scrn	TCE (ug/L)	Well	Top of Scrn	Bottom of Scrn	TCE (ug/L)
EW1	2669.7	2671.7	16	EW6	2575.2	2500.2	4.3
NZ21	2708.34	2693.34	33	EW7	2588	2543	22
NZ22	2675.71	2665.71	34	NZ37	2577.9	2567.9	8.9
NZ42	2689.1	2669.1	34	NZ48	2570.6	2550.6	2
NZ43	2702.8	2673.2	?	EW14	2575.2	2520.7	3.1
EW3	2720.63	2675.63	41	NZ76	2555.2	2535.2	ND
NZ25	2693.73	2678.73	111	EW15	2567.3	2512.3	0.9
NZ31	2659.36	2649.36	34	NZ77	2552.1	2532.1	ND
EW5	2714.83	2679.83	14	EW16	2570.4	2515.4	ND
NZ28A	?	2674.93	11	LW1	2586.4	2541.4	2.3
NZ32	2650.56	2640.56	57	NZ73	2587.6	2567.6	23
EW9	2698.9	2653.9	39	EW17	2567.4	2512.4	2.4
NZ12	2704.29	2674.29	187	MW107	2579	2559	1
NZ20	2672.95	2662.95	108	NZ41	2569.3	2554.3	?
EW10	2695.9	2663.9	2.2	EW18	2577.3	2522.3	1.8
NZ75	2701.8	2680.8	62	NZ70	2590.8	2570.8	16
EW13	2705.5	2683.5	?	NZ71	2548.7	2528.7	ND
NZ11	2702.67	2672.67	381	NZ79	2556	2536	2
NZ30	2667.51	2652.51	356				
NZ67	2710.1	2690.1	243				

The left column lists wells screened through the upper aquifer and the right column shows wells in the lower aquifer. This table indicates:

(1) EW1: GAFB should correct screen top and/or bottom elevations before any recommendations (on screened interval) can be made.

(2) EW3: Screened interval is too long to focus on mass removal of the main plume as indicated by NZ25 (between 2693 feet and 2678 feet msl).

(3) EW5: The well may be more efficient if the screens were placed at the level similar to NZ32 instead of NZ28A.

(4) EW9: The high flow rate at EW9 indicates that it is intercepting a high permeability channel. On the other hand, if the screens were placed higher, mass removal at this well may be improved.

(5) EW10 and EW13: Both extraction wells may have missed the high permeability channels such that the extraction rate and TCE concentration are low at both wells.

(6) The lower aquifer extraction wells have 50 feet or longer screens. Whether the screen intervals are designed optimally is not clear at this time. On the other hand, the above table indicates that preferential channels may exist in the lower aquifer. Also TCE is not evenly distributed vertically in the aquifer.

It appears that the well screens may not be located at optimal depths to maximize mass removal. It is recommended that new extraction wells be installed to replace ineffective ones and be designed according to the indications of the geology and plume distribution.

2. One Zone or Two Zones in Upper Aquifer

GAFB does not recogize the existence of two flow zones in the upper aquifer. However, the differences in water levels and TCE concentrations at several well pairs (two wells located next to each other but screened at different depths) indicate the two zones in the upper aquifer. The table below shows the screened interval, water level, and TCE concentrations at selected pairs of wells. All elevations are expressed in feet above mean sea level and the unit of TCE concentration is ug/L.

Well ID	Top of Screens	Bottom of Screens	Water Level 7/97	Water Level 10/97	Water Level 10/98	TCE 10/98
EW3	2720.63	2675.63	2702.57	?	?	41
NZ25	2693.73	2678.73	2704.48	2703.68	2708.28	111
NZ31	2659.36	2649.36	2653.52	?	2653.86	34
EW5	2714.83	2679.83	2685.42	?	?	14
NZ28A	?	2674.93	2702.73	2701.8	2705.07	11
NZ32	2650.56	2640.56	2651.92	?	2652.96	57
FT5	2719.81	2709.81	2714.77	2714.73	2724.36	27
FT2	2690.57	2655.57	2715.6	?	2722.97	8.8
NZ11	2702.67	2672.67	2699.06	?	2702.82	381
NZ30	2667.51	2652.51	2664.69	2664.47	2664.77	356
NZ12	2704.29	2674.29	2709.42	2708.95	2715.7	187
NZ20	2672.95	2662.95	2678.35	2678.10	2683.4	108

This table indicates water levels and/or TCE concentrations may be considerably different between the two wells within each pair. For instance, at NZ25 and NZ31, TCE concentrations are 111 ug/L and 34 ug/L, respectively. Water levels at these two wells are 2708.28 feet and 2653.86 feet above msl, respectively.

GAFB should characterize plume distribution in the shallow and deep zones (of the upper aquifer) by placing additional monitoring wells with specifically designed screen intervals. To facilitate RPO studies, detailed cross sections with measured TCE concentrations should be provided. Also, to minimize vertical migration of TCE and maximize mass removal, GAFB should install new extraction wells and screen them specifically across the deeper zone if high contamination were found there.

3. Mass Removal in Upper Aquifer

The following table summarizes groundwater extraction rates at Upper Aquifer wells. Note: extraction rates at EW-9 through EW-13 are either zero or less than 0.3 gpm.

Qtr/yr	EW1	EW2	EW3	EW4	EW5	EW9	EW10	EW12
4/97	21	6	18	7	1.5	43	0.2	0.15
1/98	24	7	20	8	0.5	50	--	--
2/98	23	7	20	8	0.5	48	0	0
3/98	19	8	13	8	0.6	35	0	0
4/98	19	7	15	8	1	35	0	0.3
TCE (ug/L)	16	12	41	38	14	39	2.2	160
Mass Removed	0.157	0.0466	0.286	0.126	0.013	0.489	0	0.0787

The last two rows list TCE concentrations and mass removal (kg) during the fourth quarter of 1998. This table suggests that:

(1) The difference in extraction rates indicates the existence of preferential channels in the Upper Aquifer. GAFB should delineate these flow channels for effective monitoring and extraction of groundwater and contaminants in the upper aquifer.

(2) Groundwater extraction rates remain the same level when water level in upper aquifer rises as a result of discharging water at the new percolation ponds. It is apparent that the flow rates are limited by aquifer characteristics (permeability, porosity, etc.) and not by hydraulic heads. The injected water is flowing to the lower aquifer through preferential channels and not being captured by upper aquifer extraction wells.

(3) The flow rates suggest that only three wells may have a considerable radius of influence (may be ~50 feet): EW1, EW3, and EW9. However, the main remedial objective for the upper aquifer is to maximize mass removal and not to achieve plume containment. GAFB should focus on removing mass at hot spots instead of pushing contaminated water to the lower aquifer.

(4) there is no apparent correlation between TCE concentration and the extraction

rate. In fact, other than EW12, EW3 and EW9 have the highest TCE concentrations among extraction wells in the upper aquifer. It follows that pumping at the preferential channels may not draw clean water to the extraction wells until the upper aquifer is clean.

GAFB should further characterize the upper aquifer, locate preferential flow channels, develop a detailed site conceptual model, and install additional extraction wells to maximize mass removal in the upper aquifer.

4. Location of Wells/Upper Aquifer

There are several areas in the upper aquifer where better delineation of the TCE plumes and better mass removal scheme are desired: (1) north of NZ75 including NZ39, (2) east of EW3, south of EW5, and north of EW1 and EW9, and (3) east of NZ7 and NZ35.

(1) In 10/98, TCE concentrations at NZ36, NZ39, and NZ75 are 24, 170 and 65 ug/L, respectively. Contaminated groundwater flows northeast to the regional aquifer, however, no effective groundwater extraction wells are located in this area (EW10 does not produce water) to remove contaminated water and to minimize impacts to the regional aquifer.

(2) EW12, NZ27, and NZ67 are historically showing high concentrations of TCE. It is expected that this highly contaminated water is flowing to the regional aquifer between EW12 and NZ67. However, no monitoring/extraction wells are available in an area east of EW3 and south of EW5 to characterize the plume and to control this undesirable migration of contaminated water. Note that EW12 and EW13 do not produce water even after water level has raised.

(3) The discharge of treated water into the new percolation ponds has pushed a block of highly contaminated groundwater to pass through NZ34 and NZ35 to the east/north east direction. No extraction/monitoring wells are available in this specific area to characterize and to control the TCE plume.

GAFB should install monitoring/extraction wells in the above described areas to fill in the data gaps and to control the TCE plume. To have optimal well designs (location, screen interval, and flow rate for each well), GAFB should conduct seismic imaging, provide detailed geological cross sections, and locate preferential flow channels in the upper aquifer.

5. Location of Wells/Lower Aquifer

Groundwater contour lines and flow direction(s) in the lower aquifer are not justified by water level data. One of the problems of GAFB's water level contours is that the wells are placed too far away from each other (over 2400 feet between NZ29 and NZ44) to assume a linear variation of water level between wells (given preferential flow channels and pumping wells exist at OU1). Also, east of NZ74, NZ79, and MW107 and south of

NZ50 and NZ72, there are no lower aquifer wells to provide data to allow the drawing of contour lines. Consequently, the plotted capture zones are not supported by field data. Because of this, more monitoring wells are needed to better characterize the TCE plume in the lower aquifer. Three areas may require immediate attention: (1) north east of NZ39, (2) east of EW12 between EW17 and EW18, and (3) east of NZ35 and south of NZ74.

(1) NZ39 was detected to contain up to 170 ug/L of TCE. Only one well, NZ72 is located down-gradient from NZ39 and GAFB should place additional monitoring wells to characterize the hydrogeology and the migration of TCE plume in that area.

(2) EW12 contains highly contaminated groundwater and the flow of groundwater may be flowing to the east by-passing the lower aquifer extraction wells, i.e., EW17 and EW18. The distance between these two wells is approximately 1700 feet. It is unlikely that the depletion zones created by pumping at these wells would have a radius of influence over 850 feet.

(3) A mass of highly contaminated water passing NZ34 and NZ35 may have migrated to the lower aquifer yet GAFB does not have monitoring wells south of NZ74 and east of NZ35.

GAFB should place monitoring wells in above described areas to further characterize the lower aquifer, the TCE plume. The need of new lower aquifer extraction wells may be indicated by new monitoring data.

6. Plume Containment/Lower Aquifer

Reduce flow rates at wells with TCE concentration less than 5 ppb: EW14 through EW18. These wells were installed during the second phase of OU1 groundwater remediation. TCE concentrations, flow rates and mass removed during the 4th quarter of 1998 are summarized in the table below:

	EW14	EW15	EW16	EW17	EW18
Total Flow	10,259,260	17,142,510	3,688,760	12,444,090	11,546,660
TCE	3.1	0.9	ND	2.4	1.8
Mass (kg)	0.12	0.0584	0	0.113	0.0787

During the fourth quarter of 1998, GAFB extracted 70,411,000 gallons of groundwater and removed about 3.52 kg of TCE at OU1 (influent TCE concentration was 6 ug/L). EW14 through 18 contributed about 55,081,280 gallons of flow which accounts to 78.2 percent of the total flow. However, only 0.37 kg of TCE were removed from these wells (about 10.5 percent of total mass removal). It is apparent that mass removal efficiency is very low at these wells.

On the other hand, by pumping at these wells and discharging such a volume of water at the new percolation ponds has caused (1) flooding of the FT19C SVE system, (2) TCE contaminated water being pushed away to the south and east, and (3) TCE contaminated water being pushed to the regional drinking water aquifer.

GAFB should stop pumping at wells EW14 through EW18. This will reduce about 80 percent of the total flow and should solve the above mentioned problems.

7. Treatment System Operation

URS has commented on GAFB's using water recycling for a proper air/water ratio. Given the influent TCE concentration of 6 ug/L, recycling of treated water would increase volume load to the system while diluting TCE concentration in the water stream to be below 4 ug/L. Treating over 500 gpm of water with less than 4 ug/L of TCE is not cost effective. MWI responded that the treatment system does not have an air regulating valve. However, this is a deficiency of the system and the cost of installing such a valve is minimal compared to the electricity being spent for the pumping and discharging of over 500 gpm of water.

GAFB should install a air regulating valve for optimal air/water ratio of the stripper.

8. System Downsizing

When GAFB turns off extraction wells EW14 through 18, the expected system flow rate will be less than 200 gpm. It is not an energy efficient operation to treat less than 200 gpm of water by using a system with 1,100 gpm in capacity.

GAFB should use a smaller treatment system with an air regulating valve.

9. Plume Containment in the Lower Aquifer

To know where contaminated groundwater may be entering the lower aquifer (from the upper aquifer), it is essential to know the history of VOC concentraions at all monitoring wells (and extraction wells) and groundwater flow paths in the upper aquifer. However, past maps of upper aquifer groundwater elevation contours are always covering the entire Base and are lacking of details in the OU1 area. It is recommended that GAFB provide OU1 groundwater elevation contour maps of the Upper Aquifer with the same scale as the TCE concentration contour maps.

Groundwater contour lines of the Lower Aquifer were drawn by connecting water level elevations measured over 2,000 feet away. This data interpretation needs several assumptions including (1) homogeneous aquifer properties between the wells, (2) no extraction/injection wells nor rivers nearby to affect groundwater flow direction, and (3) water level changes linearly with distance from one well to the other. Given the aquifer is heterogeneous, numerous extraction wells exist in the vicinity of OU1, and water flows from the upper aquifer to the lower aquifer, the contour lines are not accurately describing the migration of groundwater in the Lower Aquifer. Consequently, the plotted Lower Aquifer capture zones are not reliable. It is therefore recommended that additional monitoring wells be installed to fill in data gaps and to demonstrate plume containment in the Lower Aquifer.

10. Problems with Injecting Water into the New Percolation Ponds

The requirements for a successful water injection project are: (1) the quality of injection water is at or better than the aquifer water, (2) location of the injection well or pond should be up-gradient of the plume, and (3) the extraction system would capture the plume in the same aquifer with field demonstration.

However, only the first requirement has been met. By discharging water at the new ponds, contaminated water is being pushed to every direction. The worst problem is the contaminated water being pushed to the lower aquifer which is a regional drinking water aquifer (as stated by the Water Board). In addition, GAFB do not have adequate monitoring/extraction well system to demonstrate plume capture in the lower aquifer. MW continues to use modeling result and disregard the indication of field data. URS recommends that water injection be stopped ASAP.

By shutting off extraction wells EW14 through 18, current concerns regarding discharging water at the new percolation ponds should be lessened. GAFB should pipe the remaining water to the gulf course.

11. Groundwater Monitoring Program

GAFB should install new monitoring wells to optimize OU1 groundwater monitoring system. Before this is done, the following wells are recommended for groundwater monitoring:

Upper Aquifer:
NZ39, NZ36, EW12, NZ27, NZ67, NZ56, NZ52. These wells are located at the leading edge of the plumes. When GAFB stops discharging water into the new percolation ponds, NZ56 and NZ52 may become less important and monitoring frequency at these wells may be reduced to annually or even bi-annually.

NZ46, NZ24, NZ23: To observe western edge of the plume.

NZ75, NZ25, NZ31, NZ12, NZ20, NZ7, NZ35, NZ55: To monitor central part of the plume.

FT1, FT2, FT4, FT5: To monitor plumes in the vicinity of FT19. FT1 may be monitored annually.

NZ51, NZ68, MW35: To monitor the FT20 plume. When this plume is stabilized, these wells may be sampled annually.

Other wells to be monitored at reduced frequency: NZ28A, NZ32, NZ21, NZ22, NZ6, NZ18, MW103.

Lower Aquifer
NZ50, NZ72, NZ76, MW108, LW4, NZ77, NZ78, MW107, NZ79, NZ74, NZ2, NZ3, NZ58, NZ80, NZ60: Leading edge of the plume. Among these wells, NZ2, NZ3, NZ58, NZ80, and NZ60 may be sampled annually.

NZ73, LW1, NZ48, NZ41: For turned off extraction wells.

NZ70, NZ71: For the plume down-gradient of NZ40/NZ67.

NZ63, NZ64: Dieldrin (may be sampled annually).

Other wells to be sampled at reduced frequency: NZ57, NZ61.